

On the Nature of Syntax

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There is a tendency in science to proceed from descriptive methods towards an adequate explanatory theory and then move beyond its conclusions. Our purpose is to discover the concepts of computational efficiency in natural language that exclude redundancy, and to investigate how these relate to more general principles. By developing the idea that linguistic structures possess the features of other biological systems this article focuses on the third factor that enters into the growth of language in the individual. It is suggested that the core principles of grammar can be observed in nature itself. The Faculty of Language is an efficient mechanism designed for the continuation of movement in compliance with optimization requirements. To illustrate that, a functional explanation of syntactic Merge is offered in this work, and an attempt is made to identify some criteria that single out this particular computational system as species-specific.

Keywords: argument structure; Fibonacci sequence; language faculty; minimalism; phases; syntactic merge; third factor

1. Introduction: Natural Law and Syntactic Trees

Alongside the other two important factors — genetic endowment and experience — a third factor is particularly important to our discussion. According to Chomsky (2008), it includes the objective principles of architecture that restrict outcomes determining attainable languages. We will follow the minimalist research program in seeking to identify aspects of language that are determined by the properties of natural phenomena. At this point, to advance our understanding of the common properties of human language, we need to present further proof of the advantages which would arise from the application of

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physical laws to the analysis of syntactic structures.

Syntax is viewed in this article as a unique subtype of recursive systems designed for the continuation of movement. The Faculty of Language (FL) in the broad sense (FLB) includes a sensorimotor system, a conceptual-intentional system, and the computational mechanisms for recursion. If we accept the hypothesis that FL in the narrow sense (FLN) includes only recursion, the ideas offered in this article may help to explain what basic operations underlie FLN.

Natural Law (N-Law), a physical phenomenon exemplified as the Fibonacci patterns where each new term is the sum of the two that precede it, can be observed in language, just as it is in other mental representations (Uriagereka 1998, Carnie *et al.* 2005, Soschen 2006).¹ These structures share certain remarkable properties with the linguistic system, according to minimalism: Both of them are characterized by discreteness and economy.² Based on that, it will be shown that the same condition accounts for the essential properties of syntactic trees: binarity of branching, the mechanism of labeling, and the properties of Merge. First, the article provides a functional explanation of thematic domains and phase formation, on the example of applicative constructions. Second, it offers a principled account of label-free parallelism of phases across languages by presenting a short discussion of the Exceptional Case Marking structures. The analysis derives the types of cross-linguistically available argument representations, and explains the attested relative frequencies of various basic word order patterns.

In the present system, syntactic composition is in effect reduced to conjunction, or Merge, of two elements without asymmetry, thus eliminating the X'-level of representation. *Conjunctivism* achieves a remarkable degree of simplicity for Occam's Razor-like methodological reasons. As it is further developed to handle an increasingly broad range of constructions and theoretical considerations, it will inevitably become more complex.

The *Fibonacci sequence* (henceforth, *FS*) is one of the most interesting mathematical curiosities that pervade the natural world. These numbers are evident in every living organism. For example, they appear in the spiral shapes of seashells and in the arrangement of leaves, petals, and branches of trees:

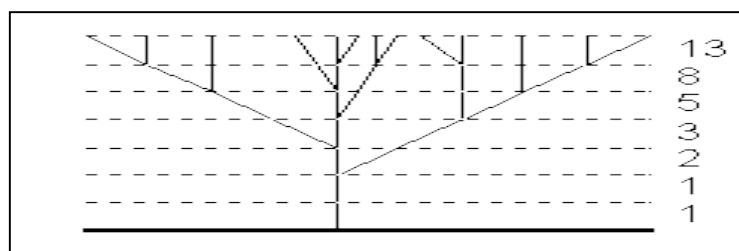


Figure 1: Fibonacci Numbers in a Tree

¹ The number of 'growing points' in plants corresponds to the Fibonacci Sequence: $X(n) = X(n-1) + X(n-2)$: {0, 1, 1, 2, 3, 5, 8, 13, ...}. The limit ratio between the terms is .618034..., the Golden Ratio.

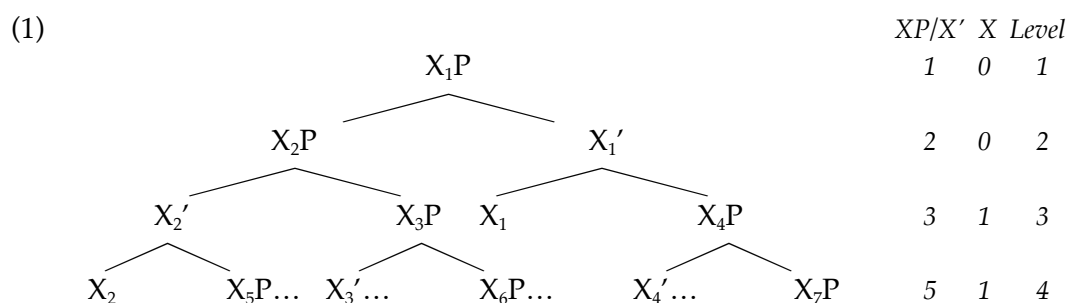
² For a good overview of the roots and core ideas of minimalism, see Boeckx (2006).

Early approaches to FS in nature were purely descriptive with a focus on the geometry of patterns. Later, Douady & Couder (1992) developed a theory of plant growth (phyllotaxis), which explained the observed phenomenon as following from efficient space filling. A particular pattern related to maximizing space is important in the case of closely-packed leaves and branches, because it ensures maximum exposure to the sun. This system is based on simple dynamics that impose constraints on the number and order of constituents to satisfy optimal conditions. Successive elements of a certain kind form at equally-spaced intervals of time on the edge of a small circle, representing the apex. These elements repel each other (similar to electric charges) and migrate in a radial manner at some specified initial velocity. As a result, motion continues and each new element appears as far as possible from its immediate successors. In humans, the Golden Ratio appears in the geometry of DNA and physiology of the head and body. On a cellular level, the '13' (5+8) Fib-number present in the structure of microtubules (cytoskeletons and conveyor belts inside the cells) may be useful in signal transmission and processing. The brain and nervous systems have the same type of cellular building units, so the response curve of the central nervous system may also have FS at its base. This suggests a strong possibility that N-Law or general physical laws that ensure efficient growth apply to the universal principles that govern linguistic representations as well.

As has already been mentioned, it was confirmed recently that syntactic structures exhibit certain mathematical properties. Like other systems that comply with N-Law, tree structures are maximized in such a way that they result in a sequence of categories that corresponds to FS. The syntactic tree is generated by merging two elements; the next operation adds a newly introduced element to the already formed pair. Each item is merged only once; every subject/specifier and every object/complement position is filled. In the traditional sense of Chomskyan X-bar theory, a label immediately dominated by the projection of another category is an XP (phrase).³ Other non-terminal nodes are annotated as X', and Xs are 'heads'. If $XP(n)$ is the number of XPs in the n th level, then $XP(n) = \text{Fib}(n)$. This property is true of all trees that are maximized by having specifiers and complements filled.

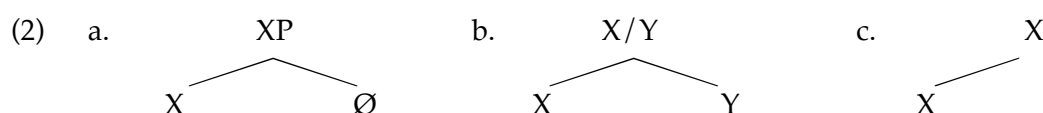
In (1) below, one can see that N-Law provides an external motivation for Merge to distinguish between syntactic labels in a particular way. Determining whether a node is XP or X follows directly from the functional pressure of cyclic derivation. The Fib-based system distinguishes between *sums of terms* (XP and X') and *single terms* (X), rather than between either XP/X' or X'/X: Level 2 has one XP and one X', Level 3 has one X' and one X. The assumption that syntactic structures have an intermediate X' projection does not hold in the present system: Basic representations appear to be monadic — cf. the dyadic model of X-bar theory, for example; see also Collins (2002) on the elimination of labels.

³ The Fibonacci sequence in a tree is related to the fact that each node dominates exactly one maximal projection. Thanks to Hans Broekhuis (p.c.) for pointing this out. Possibly, hierarchical structures created by adjunction (pair-Merge, in the Chomskyan system) comply with NL as well. Rubin (2003) proposes the (obligatory) existence of a functional category, Mod, in the structure of adjuncts ([Mod [[YP] Adjunct]]) that is parallel in nature to functional categories in clauses.



What is the reason behind compositionality that motivates combining exactly two terms in a set? The requirement to achieve tree maximization explains why the trees are constructed out of binary units. If Merge were allowed to optionally select three terms and combine them into a ternary structure, then FS of maximal categories would disappear. The sequence where each term A_n combines with the two that precede it is $\{1, 1, 1, 3, 5, 9, 17, 31, 57, \dots\}$. The ternary branching system shows a Fib-like sequence; however, the arrangement of elements displays a ratio different from the Golden Ratio, which fails to meet the condition of optimization. As a result, ternary branching or any operation that merges more than two syntactic elements is disallowed.⁴

The requirement to fill specifier and complement positions faces a problem: It creates a 'bottomless' tree by eliminating a line with only terminal Xs (Carnie 2002). However, real sentences always have an ending point. In the present work, the solution to this problem lies in redefining syntactic binarity to include zero-branching — in other words, to start FS with 0 instead of 1. This follows directly from the requirement of N-Law: Each successive element is combined with a sum of already merged elements, not with one. For example, merging 2 with 1, where 1 is a sum of 1 and 0, yields a new element 3, while merging two elements one of which is not a sum ($2+0$) does not. Consequently, (2a) and (2b) are instances of Merge, while (2c) is not.



When the sum of terms is present at each step, it provides the 'bottom line' in the syntactic tree. The newly introduced *zero-Merge* (\emptyset -Merge) distinguishes between terms $\{1\}/X$ and singleton sets $\{1, 0\}/XP$. This way the process of merging *terms* with *sets* is initiated, to ensure continuation of motion. Following from that, *singleton sets are indispensable for recursion*.

The suggestion to regard an empty element as functional in Merge has serious consequences for the theory of binary branching. The minimal building block that enters into linguistic computation is re-evaluated to include \emptyset -Merge, and is identified as the product of \emptyset -Merge.⁵ As a result, binarity is preserved,

⁴ Chomsky (2007a: 8) asserts that "Merge cannot create objects in which some object W is shared by the merged elements X, Y . It has been argued that such objects exist. If so, that is a departure from SMT, hence a complication of UG".

⁵ For the discussion of zero-branching constructions, see, e.g., Roodenburg (2004).

while there is no problem caused by the requirement to fill specifier and complement positions. XPs and Xs are disambiguated, which eliminates the necessity to proceed with further branching below the bottom level.

Furthermore, the proposed analysis along the lines of N-Law clarifies the notion of labeling, and answers the question why labels can be disposed of in syntax. If the same element can be represented as either a singleton set or a term, it follows that X and XP are not syntactic primitives.⁶ The idea that constituent structures are labeled appears to be a stipulation; this part of Merge should be abandoned in favor of a rule that offers a more adequate explanation.⁷ As grammar evolves toward a generalized syntactic representation, the only necessary mechanism is not the one that determines which node is XP and which is X or X', but the one that determines whether a node is a result of Merge or not, thus eliminating labels altogether.

In sum, in the present system,

- a bottom node is identified as either XP or X, depending on whether or not it undergoes \emptyset -Merge;
- a node is identified as either XP or X, depending on whether or not it is the result of Merge.

2. Merge and Displacement

2.1. Constraints on External Merge

Syntactic Merge builds elementary trees and combines them into larger structures. Under External Merge (henceforth, EM), α and β are separate objects; under Internal Merge, one is part of the other, and Merge yields the property of displacement (Chomsky 2001).⁸ The argument structure is the product of EM. The application of Fib-like logic to the analysis of thematic domains makes some

⁶ Heads can behave like phrases and *vice versa*, according to Carnie (2000), Collins (2002), and Chomsky (2004, 2008). There exist numerous instance of label-switching between X and XP: *that* may behave as X and XP in the same sentence (i).

(i) $_{XP}$ That $_{X}$ that is, is; $_{XP}$ that $_{X}$ that is not, is not — we all know $_{XP}$ that.

In addition, a group of Russian nouns (*toska* 'boredom', *grex* 'sin', *vremja*, *pora* 'time', etc.) can be either predicate heads (ii) or arguments (iii).

(ii) Vam $_{X}$ grex žalovat'sja.
you.DAT sin complain.INF
lit. 'For you a sin to complain.'

(iii) $_{XP}$ Grex budet iskupljon.
sin will.be redeemed
'The sin will be redeemed.'

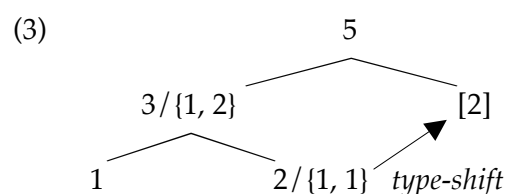
⁷ "It seems now that much of the architecture that has been postulated can be eliminated without loss, often with empirical gain" (Chomsky 2007b: 24).

⁸ The pressure for the tree to be maximized justifies the basic principle of organization in both types of Merge. Move is just one of the forms of Merge: EM induces IM by virtue of the fact that already conjoined elements have to be *linearized* at the level relevant for pronunciation.

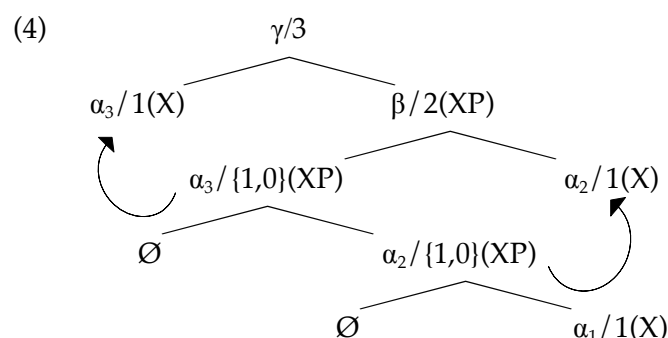
interesting predictions about the constraints on EM, such as a fixed number of nodes (1, 2, and 3) in these domains.

Assume that \emptyset -Merge is the operation responsible for constructing elementary *argument-centered* representations, the process that takes place prior to lexical selection.⁹ As already pointed out, this kind of Merge is relevant at the point where a distinction between *terms/entities* — represented as $\{1\}/X$ — and *sets* — or $\{1, 0\}/XP$ in the present system — is made.

The functional pressure of cyclic derivation to merge terms of *different types* only accounts for the *type-shift*, or type-lowering, from *sets* to *entities* at each level in the tree. As a result, at some level, a node is XP (set); at the next level, it is X (entity). The Impenetrability Condition ensures the *continuity* (vs. discreteness) of constituents: Once X is formed, it cannot be broken up into parts. To clarify this point, (3) shows an example of a type-shifting operation in an FS-based numeric system. At the point where 3 is merged with 2, element 3 is the sum of 1 and 2 (set $\{1, 2\}$, XP), but 2 is a single entity ($[2]$, X).



Assume that in a tree built by EM in compliance with N-law, the recursively applied rule adjoins (in a bottom-up manner) each element to the one that has a higher ranking, starting with the term that is ' \emptyset -merged first'. Recall that in the present system, FS starts with 0: $\{0, 1, 1, 2, 3, 5, \dots\}$. In (4), α_1 is entity, α_2 and α_3 are singleton sets, and β and γ are non-empty (non-singleton) sets. At each level, the Impenetrability Condition induces a type-shifting operation from *sets* to *entities*. The type of α_2 is shifted from *singleton set* (XP) to *entity* (X), to be merged with α_3 (XP); the type of α_3 is shifted from *singleton set* (XP) to *entity* (X) and merged with β (XP).

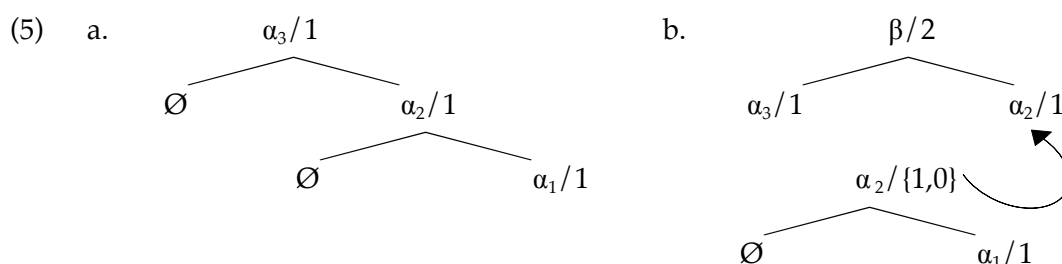


There is a limited array of possibilities for EM, depending on the number of

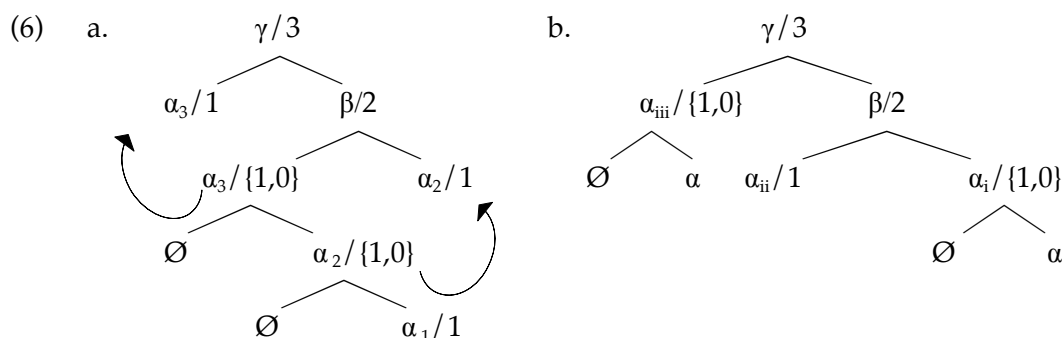
⁹ Chomsky (2007a) specifies other argument constructs, such as Pritchett's (1992) theta-driven model of perception. In such and similar models, a verb is theta-role assigner. In a proposed *primitive* model of EM, the only function that matters is the one that identifies *arguments*.

positions available to a term adjoining to the tree. This operation either returns the same value as its input (\emptyset -Merge) or the cycle results in a new element (N-Merge).

- Term α_1 can be \emptyset -merged *ad infinitum* (5a): The function returns the same term as its input and the result are zero-branching structures.
- \emptyset -merged α_1 is type-shifted to α_2 and N-merged with α_3 (5b): The process creates a single argument position made explicit by intransitive (*unergative* and *unaccusative*) verbs, e.g., in sentences such as *Eve₁ laughs* or *The cup₁ broke*.¹⁰



- Terms α_2 and α_3 assume positions where each can be merged with a non-empty entity: The result are two argument positions, e.g., *Eve₁ saw Adam₂* (6a).¹¹
- There are three positions to accommodate term 1 (i–iii): This may explain why the number of arguments permitted is limited to three in maximal thematic domains, represented, by the sentence *Eve₁ gave Adam₂ an apple₃*, for example (6b).



¹⁰ Certain verbs of spatial configuration, such as *lean*, are unergative with an agentive subject but unaccusative when they take a non-agentive subject (Levin & Rappaport Hovav 1995). A term may undergo \emptyset -Merge either first or second, which explains why the same verb appears with either *agent* (\emptyset -merged first) or *theme* (\emptyset -merged second).

¹¹ The supporting evidence that a term may undergo \emptyset -Merge either first or second comes from Japanese. In (i), the argument position of *girl* is ' \emptyset -merged second' in the matrix clause and ' \emptyset -merged first' in the subordinate clause.

(i) Yoko-ga kodomo-o koosaten-de mikaketa onnanoko-ni koe-o kaketa.
 Yoko.NOM child.ACC intersection.LOC saw girl.DAT called
 'Yoko called the girl who saw the child at the intersection.' (Pritchett 1992)

We have shown so far that the N-Law logic can be applied to the analysis of EM to account for the limited number of argument positions in thematic domains. The argument structure is built upon hierarchical relations; the term that is \emptyset -merged first has the highest ranking.¹²

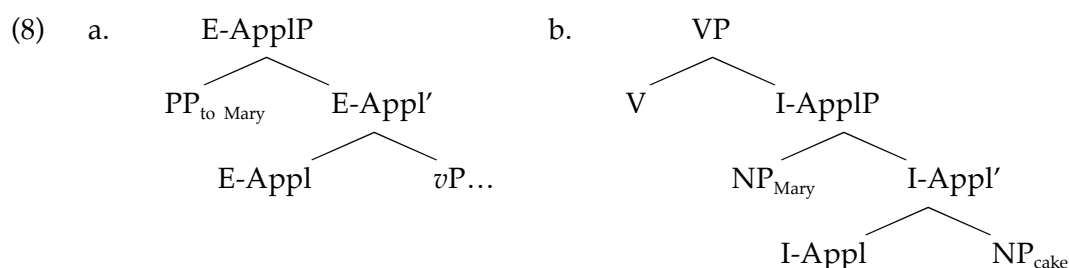
2.2. Maximal Thematic Domains

The applicative and double object constructions of the kind *John baked Mary a cake* and *John gave Mary a cake* vs. *to-* and *for-* constructions *John baked a cake for Mary* and *John gave a cake to Mary* have a maximal number of arguments, which is essential for the explanation of limitations imposed on thematic domains.

Recent research on argument structure has resulted in a complex representation that consists of two levels: One involves two individuals, and another expresses an individual-event relation (Marantz 2003, McGinnis 2001, Pylkkänen 2001, 2003). Sentences like *John baked/gave [Mary]_{individual} [a cake]_{individual}* are of the first type; other structures, such as *[John baked a cake]_{event} [for Mary]_{individual}* or *[John gave a cake]_{event} [to Mary]_{individual}* belong to the second.

It was suggested that a relation between individuals is established by means of Event Applicative, heading an E-AppIP ((7a,b) for (8a)), and by means of Individual Applicative, heading an I-AppIP ((7c) for (8b)).¹³

- (7) a. John gave a cake_{event} to Mary_{individual}.
 b. John baked a cake_{event} for Mary_{individual}.
 c. John baked / gave Mary_{individual} a cake_{individual}.



The generalized thematic structure that incorporates both AppIPs is shown in (9), where Y_E is E-AppI and Y_I is I-AppI.

- (9) a. [_{VP} v [_{E-AppIP} E-AppI [_{VP} V [_{I-AppIP} I-AppI NP]]]]
 b. [_{VP} v [_{Y-EP} Y_E [_{VP} V [_{Y-IP} Y_I XP]]]]

¹² Hierarchy is assumed to be automatic for recursive operations (Chomsky 2008).

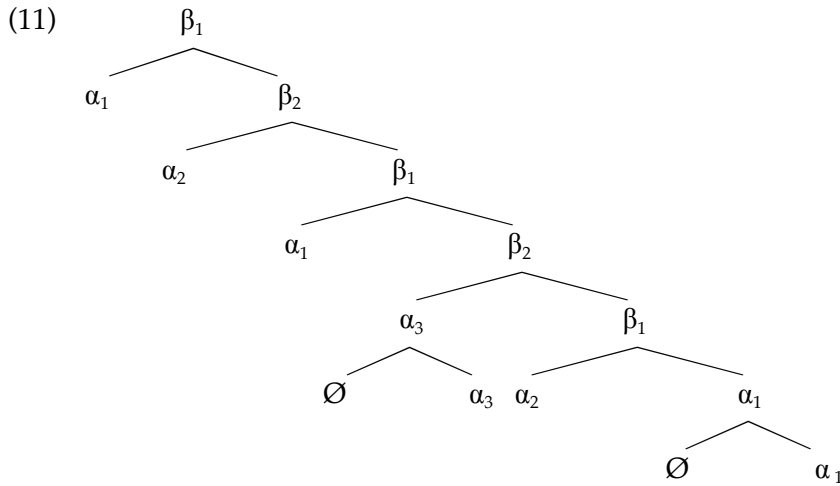
¹³ This classification is viewed as necessary to account for the difference in semantic interpretation. See Erteschik-Shir (1979) and Snyder (2003) on the semantics of the English *to*-dative and double object constructions with *give*. Studies of texts show that there is a preference for the double object construction since recipients are typically human and, therefore, likely to be given, while themes are typically inanimates and, therefore, less likely to be given.

- (i) a. Nixon's behavior gave Mailer an idea for a book.
 b. *Nixon's behavior gave an idea for a book to Mailer. (Snyder 2003)

When the trees are maximized and all positions are filled, as in (10), the sum of heads, specifiers, and complements yields a maximal space of 13 — the Fib-number.

- (10) a. $[_{XP} \ vP \ [_{v'} \ v \ [_{XP} \ VP \ [_{V'} \ V \ [_{XP} \ Y_IP \ [_{Y'} \ Y_I \ XP \]]]]]]$
 b. $[_{XP} \ vP \ [_{v'} \ v \ [_{XP} \ Y_EP \ [_{Y-E'} \ Y_E \ [_{XP} \ VP \ [_{V'} \ V \ XP \]]]]]]$

In theory, maximal thematic domains may be constructed in a certain way to accommodate all possible *argument* configurations:¹⁴



There does not seem to be any intrinsic reason why thematic domains should be spaces with a particular number of nodes — 13. However, from a broader perspective, there is a sense in which the domains under discussion are maximal. As was already pointed out, the Fib-number ‘13’ is present in the structure of microtubules; the brain and nervous systems have the same type of cellular building units. This may account for the limitations imposed on thematic domains — the core units built by syntactic Merge.¹⁵

3. Internal Merge

3.1. (Non-)Propositionality of Phases

The application of Fib-like logic not only makes interesting predictions about the constraints on EM but also explains the properties of Internal Merge (IM), an operation relevant at the point of pronunciation that assigns the order to lexical items. As was already shown, EM creates a hierarchical structure with a restricted number of arguments. It is possible that optimization requirements also justify the principle of organization in IM, a highly efficient mechanism

¹⁴ See section 4 for further elaboration as to why this possibility is strong, and the relevant one.

¹⁵ Interestingly, in (11) the number of binary chunks is 7, which roughly corresponds to the human short-term memory capacity with an average of 7±2 limit.

designed for the continuation of movement in derivations. In this sense, restructuring is not an imperfection but a necessity to satisfy conditions on the ordering of syntactic elements at the point of pronunciation. The explanation of IM is very straightforward if we assume that derivations proceed by phases, and that movement depends on the qualification of phrases as phases.¹⁶

Are phases propositional? According to Chomsky (who suggests that *vP* and *CP* are phases, while *VP* and *TP* are not), the answer is most probably yes. Only a fully-fledged phrase can qualify as a phase. *Bill likes Mary* is possible because there is an additional position *x* in [*Spec, vP*] to accommodate the NP *Bill*. This position is projected by the phasal head *v* in [_{*vP*} *x*_{*Bill*} *v* [_{*VP*} *likes Mary*]]. In contrast, *likes Mary* is not a phase as there is no available position *x* to accommodate the NP *Bill*; representations of the kind [_{*VP*} *x* *V NP*] are not feasible. As was already discussed, ternary branching or any operation that merges more than two syntactic elements is disallowed in syntax.

The analysis developed in this paper leads one to the conclusion that any XP can in principle head a phase. This idea is based primarily on regarding phases in a particular way. Phases are characterized by their *ability to induce a new cycle* (to ensure continuation of movement) by projecting extra *Spec* positions, thus providing a ‘landing site’ for a moved constituent.¹⁷ In this sense *VP* and *TP*, for example, may constitute *internal* phases, however incomplete.¹⁸ In the next section, phases are redefined as *maximal* (propositional) and *internal*, i.e. *minimal* (non-propositional), constructs. Then it is shown that the formation of a *minimal* phase should be regarded as language-specific.

3.2. *Minimal and Maximal Phases*

A ‘derivation-by-phase’ approach to applicative and double object constructions constitutes a crucial step toward an explanatory account of phase formation. As previously described, *I-Appl* establishes a relation between two individuals, while *E-Appl* is instrumental in expressing a relation between an individual and an event. It was maintained in the above-cited literature that only the relation between individuals and events constitutes a phase, in order to provide an account of passive formation in these constructions. It was also concluded that the absence of an extra *Spec*-position in *I-ApplP*, the Individual-Applicative Phrase, disqualifies it from phasehood, by blocking *DO*-movement, i.e. movement by the direct object. As a result, sentences like *A cake was baked Mary t_{cake}* and *A cake was given Mary t_{cake}* are unacceptable. At the same time, sentences of the

¹⁶ See Chomsky (1995, 2004, 2007a, 2007b) for the discussion of phase formation. See also Bošković (2002), Epstein & Seely (2002), Legate (2003), Müller (2004), Suranyi (2004), and Wexler (2004).

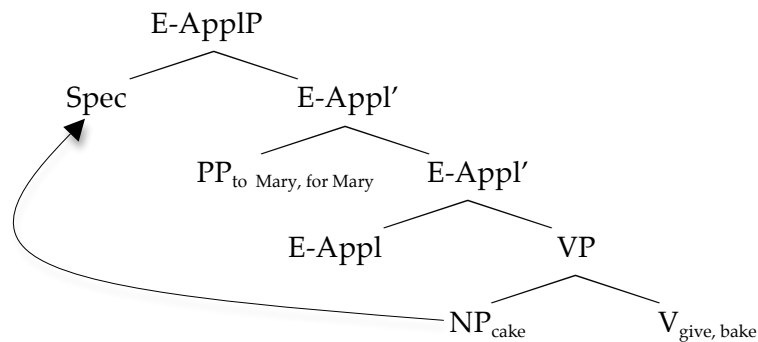
¹⁷ Thinking positively, we are interested in what prompts movement, the steps by which it proceeds — and only then considering non-phasal configurations to account for the *barriers* to movement.

¹⁸ This distinction between *internal* and *complete* phases is analogous to what is found in other natural systems of efficient growth. In Figure 1, the tree constitutes a *complete* stage/phase, while its constituent parts (i.e. a branch, a flower) are *internal* stages in the development of the tree. Meanwhile, both types of phases comply with the optimization requirement imposed by N-Law.

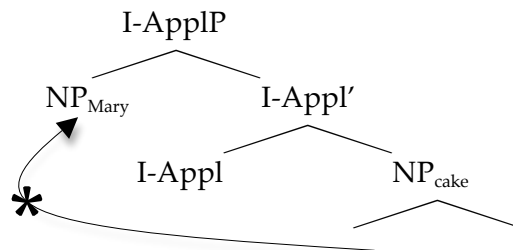
kind *A cake was baked* t_{cake} *for Mary* and *A cake was given* t_{cake} *to Mary* are grammatical due to DO-movement of NP_{cake} to [Spec,E-AppIP], which is a phase.¹⁹

The distinction between the two structures (12a) and (12b) below is in the movement of object to subject position in E-AppIP. This movement is possible because E-AppI projects an extra Spec-position, while I-AppI does not, rendering (12b) ungrammatical. The DO *cake* can raise to the subject position in (12a), but not in (12b).²⁰ Based on this analysis, the conclusion has been reached that only a propositional (eventive) E-AppIP, but not I-AppIP, constitutes a phase.

- (12) a. A cake was given to Mary / baked for Mary.



- b. *A cake was given / baked Mary



Recently, however, it has been shown that Individual-Applicative Phrases behave like phases in certain languages, by allowing DO-movement and blocking IO-movement in passives, as (13) sketches (Soschen 2005). In synthetic (inflectional) languages, such as Russian, Italian, and Hebrew, I-AppIPs exhibit the properties of minimal (min)-phases.²¹

¹⁹ Note that indirect object or IO-movement is ok: *Mary was given/baked a cake*.

²⁰ Move is driven by a need to check a feature (Chomsky 1995, Richards 2001). In passives, direct object moves to [Spec,E-AppIP] to check *uninterpretable* features on a phase head. When the head — in this case, I-AppI — does not have these features, no Spec-position is projected, and movement is blocked.

²¹ As one example, applicative constructions in Kinyarwanda (Bantu) exhibit either indirect (i) or direct (ii) object movement in passives. There is no morphological evidence (i.e. PP) that (ii) involves E-AppIP; the conclusion that E-AppIP is a phase but I-AppIP is not relies solely on object movement.

- (13)
- Italian, Russian, Hebrew, Kinyarwanda*

$$[_{VP} \ V \ [_{I-AppIP} \ DO \ [_{I-AppIP} \ IO \ [_{I-AppI'} \ I-AppI \ t_{DO}]]]]$$

I-AppIP: minimal phase

In contrast, in analytical languages I-AppIP is not a phase but *vP* is:²²

- (14)
- English, Icelandic*

$$[_{vP} \ IO \ v \ [_{VP} \ V \ [_{I-AppIP} \ t_{IO} \ [_{I-AppI'} \ I-AppI \ DO]]]]$$

vP: maximal phase

Both synthetic and analytical groups have maximal phases such as E-AppIP:

- (15)
- Italian, Russian, Hebrew, Kinyarwanda, English, Icelandic*

$$[_{E-AppIP} \ DO \ [_{E-AppIP} \ PP \ [_{E-AppI'} \ E-AppI \ [_{VP} \ V \ t_{DO}]]]]$$

E-AppIP: maximal phase

The absence of min-phases is characteristic of languages with fixed word order. When subject and object have to be ordered with respect to the verb, *vP* is the phase. The process is different when relations between words are established by means of inflections and the requirement of ordering is not so strict.^{23,24}

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- (i) Umukoóbva_i a-ra-andik-ir-w-a _{t_i} íbárúwa n'úmuhuúngu.
 girl SP-PRES-write-APPL-PASS-ASP letter by.boy
 'The girl is having a letter written for her by the boy.'

- (ii) Íbárúwa_i i-ra-andik-ir-w-a umukoóbva _{t_i} n'úmuhuúngu.
 letter SP-PRES-write-APPL-PASS-ASP girl by.boy
 'The letter is written for the girl by the boy.' (McGinnis 2001)

²² There is a restriction on movement of the direct object of AppIP *Haraldur* in Icelandic (i) but not in Italian (ii). A unifying explanation of these constructions can be provided if I-AppIP is a phase in Italian but not in Icelandic.

- (i) *I-AppIP is not a phase*
 a. Jón telur [mér_i virðast _{t_i} [Haraldur hafa gert þetta vel]].
 John.NOM believes me.DAT seem.INF Harald.NOM have.INF done this well
 'John believed Harald to seem to me to have done this well'.
 b. *Jón telur [Haraldur_i virðast mér [_{t_i} hafa gert þetta vel]].

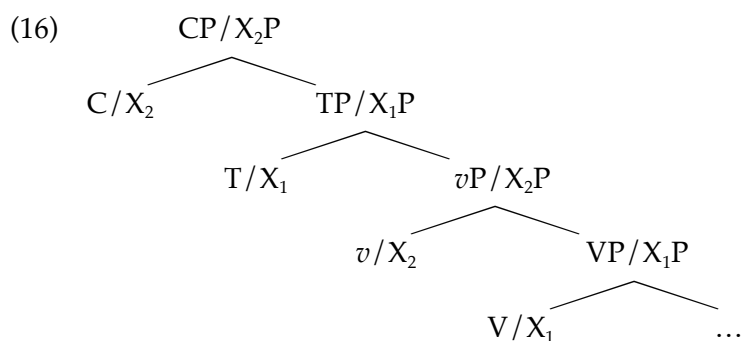
- (ii) *I-AppIP is a phase*
 Gianni non [gli sembra [_t fare il suo dovere]].
 Gianni.NOM not him.DAT seems do.INF the his duty
 'Gianni does not seem to him to do his duty.'

²³ When English is compared to languages with overtly marked dative case in sentences with *give*, the recipient NP in the *to*-construction is sometimes equated with dative NP. In this sense, those languages lack constructions with I-AppIP (they have only E-AppIP). This does not explain the cross-linguistic distribution of object movement and consistency of passive formation in both applicative and double object constructions with *give*, *send*, and the like.

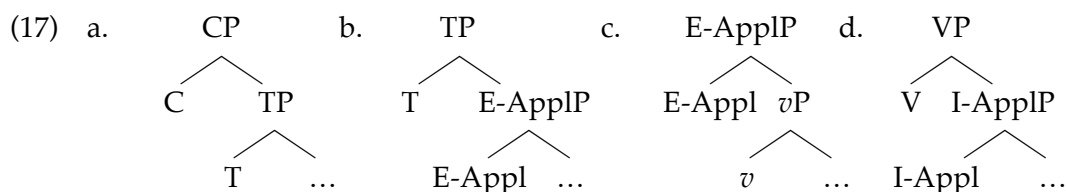
²⁴ There is additional evidence that syntactic structures that express a relation between *individuals* should be considered more basic than those expressing a relation involving events. In languages with phasal I-AppIPs, sentences such as *A boy tore a girl a skirt*, *My*

3.3. Phase Parallelism

As was already proposed, phase selection is language specific, while any syntactic phrase may in principle constitute a phase. These label-free phases — compared along the lines of their configurations only — exhibit parallelism. For example, $[_{CP} C [_{TP} T]]$ and $[_{vP} v [_{VP} V]]$ are parallel because both have a no-label dyadic representation $[_{X_2P} X_2 [_{X_1P} X_1]]$ at their base (16). The difference between two types of phases is in whether a phase is *minimal/incomplete* (X_1P) or *maximal* (X_2P).



At some level, $[_{CP} C [_{TP} T]]$ and $[_{VP} V [_{I-AppIP} I-AppI]]$ are parallel (17). If I-AppIP can in principle constitute a minimal phase, then one may expect to identify other minimal phases (such as TP) in a language where I-AppIP is phasal.²⁵



What happens when TP behaves as a minimal phase? A certain class of verbs assigns structural case to an embedded subject in Exceptional Case Marking (ECM) constructions in sentences such as *Eve wanted Adam_{ACC} to taste an apple*, where the NP *Adam* is assigned accusative Case by the matrix verb *want*. This fact was accounted for in terms of CP-reduction. If this is a universally accessible rule, it is not clear why many languages — with Hebrew, Spanish, and Russian among them — lack ECM:

(18) *Hebrew*

- a. *Hava racta Adam lakahat et ha-tapuax.
 Hava.NOM wanted Adam.ACC take.INF ACC the-apple
 'Eve wanted Adam to take the apple.'

friend broke me glasses, She fixed her neighbor a car, and A daughter washed her mother the dishes are regular grammatical structures.

²⁵ Recall that in the present system, phases are primarily characterized by their capacity to project extra Spec-positions, to ensure continuation of movement. It is possible that *minimal* phases are *incomplete*. TP is not a *maximal* phase; it is internal to CP and dependent on CP.

- b. Hava racta še Adam ekah et ha-tapuax.
Hava.NOM wanted that Adam.NOM would-take ACC the apple
 (lit.) 'Eve wanted that Adam took the apple.'

(19) *Spanish*

- a. *Eva quisiera Adam tomar la manzana.
Eva.NOM wanted Adam.ACC take-INF the apple
 'Eve wanted Adam to take the apple.'
- b. Eva quisiera que Adám tomara la manzana.
Eva.NOM wanted that Adam.NOM would-take the apple
 (lit.) 'Eve wanted that Adam would take the apple.'

(20) *Russian*

- a. *Jev-a xotela Adam-a vzjat' jabloko.
Jev.NOM wanted Adam.ACC take-INF apple
 'Eve wanted Adam to take the apple.'
- b. Jev-a xotela čtoby Adam vzjal jabloko.
Jev.NOM wanted that Adam.NOM took apple
 (lit.) 'Eve wanted that Adam took the apple.'

The explanation of this contrast lies in the distribution of the language-specific types of phases. The absence of ECM can be accounted for if a language has minimal (internal) phases, and one such phases is TP. The explanation is as follows. Once the lower T_{INF} -phase is complete, subject NP in [Spec, T_{INF} P] requires Nominative Case that cannot be assigned in this position due to the properties of T_{INF} . The conflict between Case requirements and phasal status of TP cannot be resolved, and derivation crashes. In English, TP is not a phase, and subject moves to object position of matrix verb to receive Accusative Case.²⁶

For the same reason, these languages lack Optional Infinitival Stage. English-speaking children at some stage between 1;10-2;7 on occasion omit TPs by producing sentences such as *Mary like John* (Wexler, 1998). Cross-linguistic data shows that this stage is absent in Polish, Russian, Italian, and Spanish. Evidently, minimal phases such as TP cannot be omitted even at an early stage of language development. The cross-linguistic distribution of Optional Infinitives in child language is consistent with the proposed universal phase parallelism and the existence of two types of phases.

3.4. *Strict Cycle Condition*

Chomsky (1973: 243) states the Strict Cycle Condition as follows: "No rule can apply to a domain dominated by a cyclic node A in such a way as to affect solely a proper sub-domain of A dominated by a node B which is also a cyclic node." The Strict Cycle Condition is borne out in Russian, a language characterized by

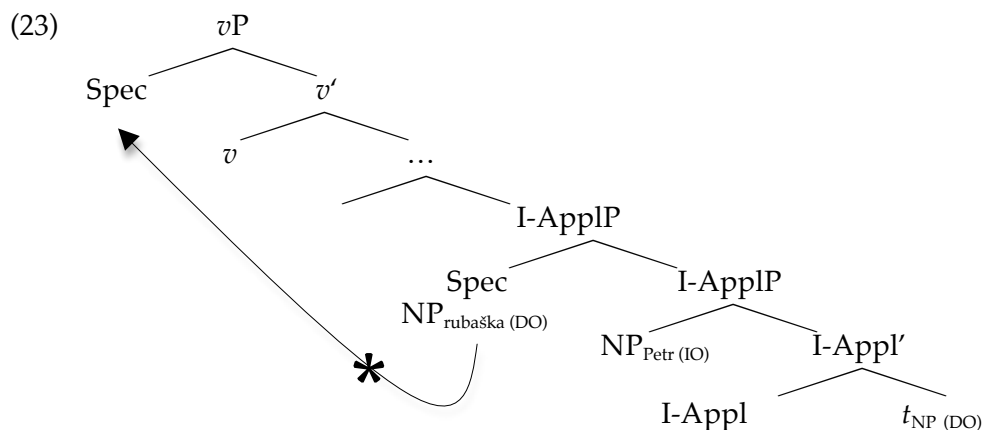
²⁶ When nominative Case assignment is unnecessary (e.g., in *Eve wanted PRO to taste an apple*), the derivation survives in a language characterized by min-phases (e.g., the corresponding Russian *Jeva xotela vzjat' jabloko*).

min-phases that allow DO-movement (21). This blocks IO-movement (22).²⁷

- (21) a. Rubaška byla vyšita / dana Petru.
shirt.NOM was embroidered / given Peter.DAT
 (lit.) 'A shirt was embroidered Peter.'
 b. [_{vP} DO *v* [_{I-AppIP} *t*_{DO} [_{I-AppIP} IO [_{I-AppI} *t*_{DO}]]]]
I-AppIP: minimal phase
- (22) a. *Petr byl vyšit / dan rubašku.
Peter.NOM was embroidered / given shirt.ACC
 'Peter was embroidered / given a shirt.'
 b. *[[_{vP} IO *v* [_{E-AppIP} E-AppI [_{VP} V [_{I-AppIP} [_{I-AppIP} *t*_{IO} [_{I-AppI} DO]]]]]]]]

The above restriction complies with the Phase Impenetrability Condition (PIC) — it requires that the domain of a phase be opaque; only the edge and the head are visible to later syntactic operations. From a more general perspective, in a system where $X(n) = X(n-1) + X(n-2)$, GR — the Golden Ratio — between the terms is preserved only when each term is combined with the one that *immediately* precedes it. Once a phase is complete, it is impossible to extract yet another element from its domain. For example, 5 is a sum of 3 and 2. If the sum were formed by adding 1 (instead of 2) to 3 etc., a sequence would yield (1, 1, 2, 3, 4, 6, ...), violating GR.

Among other things, this explains why DO-movement bleeds IO-movement in Russian applicative constructions, and presents yet another proof that I-AppIP is a phase in this language:



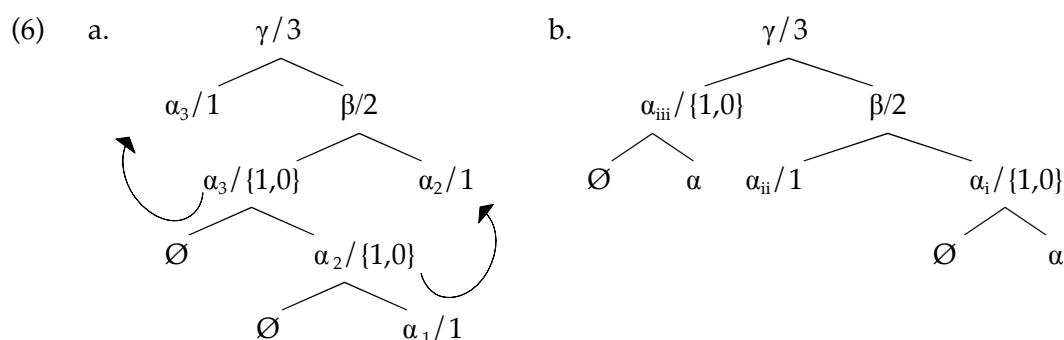
3.5. Spell-Out and Interpretation of Phases

Chomsky (2001) identifies *vP* and CP as fully-fledged phases, relatively independent at the interface and spelled out cyclically. Epstein & Seely (2002) find this specification problematic: How do we know they are independent at the

²⁷ In (21b) and (22b), X'-nodes are subsumed. In (23) below, the nodes E-AppI' and V' are subsumed. This is not a contradiction to the claim that X'-levels should be eliminated. At present, the existing X'-model is indispensable for syntactic representations.

interface if Spell-Out applies before the interface is reached? The explanation is as follows: These are the phases within which all theta-roles are discharged, evidence that the underlying label-free argument-centered component is preserved throughout derivations.

Consider, for example, the sentences *John left his girlfriend with a baby* and *John left his girlfriend with a smile*. The interpretation of these and similar sentences (inspired by Chomsky's examples) varies, which can be made explicit by the extended semantics of V (meaning 'John impregnated his girlfriend' vs. 'John walked away from his girlfriend with a smile on his face'). The argument-centered representations below make the distinction transparent. There is no requirement to extend V_{left} : *John left his girlfriend (with a smile)* has two obligatory participants ((6a), repeated here), while *John left his girlfriend *(with a baby)* has three ((6b), also repeated here). Clearly, a rule that determines the number of arguments and their hierarchy is preserved through derivations until PF is accessed.²⁸



At the end of each phase, derivations are sent off to PF (Phonological Form, Spell-Out) and LF (Logical Form, Interpretation). The next important question is how PF and LF are derived in a language system with two types of phases — maximal and minimal. According to Epstein & Seely (2002), some features of lexical items are illegitimate at one or the other interface. For instance, the pronoun *him* seems synonymous with *he*, even though their PF-interpretations are distinct. It was assumed that unvalued lexical features are illegible at both LF and PF; valuation, however, is a necessary, but not sufficient, condition for LF convergence. The Case feature of a DP/NP may be valued by the operation Agree, but a valued Case feature is by hypothesis still not interpretable at LF, and can be interpreted only at PF.

Let us assume that this interface disassociation is crucial to the distinction between min- and max-phases. If (all) languages have max-phases (CP, E-AppIP), and certain languages in addition have min-phases (TP, I-AppIP), heads of min-phases ensure realization of Agree for the continuation of movement, but it is max-phases that are sent to PF. One example are 'garden-path' sentences (Gibson

²⁸ Argument-based representations in (23) above may also provide valuable insight into the existing similarity between applicative and double object constructions. Even though the former has an optional argument (*John baked (Mary) a cake*) and the latter has three obligatory arguments (*John gave Mary a cake*), object movement in passives shows consistency in both: These constructions have a common core.

2000). The sentence [_{CP1} *The horse raced past the barn*] is interpreted as complete; the resultant derivation is sent to PF and LF. In *The horse raced past the barn fell*, this constituent CP₁ is interpreted as NP — [_{CP2} [_{NP} *The horse raced past the barn*] *fell*]. At the end of derivation, a completed max-phase (CP₂) is sent to PF. To conclude, in a label-free system underlying syntactic representations,

- phase heads are characterized by their ability to project Spec-positions;
- any phrase may in principle constitute a phase;
- phases can be compared along the lines of their configurations;
- all languages have maximal (propositional) phases, certain languages also have minimal/internal phases;
- at the end of derivation, maximal phases are sent to PF.²⁹

4. Argument-Centered Representations

4.1. ‘Verbless’ Languages

A relation between individuals may constitute a phase and induce movement (recursion). This means that the core syntactic representations do not necessarily require a verb. The argument-centered logic of minimal syntactic units relies to a large extent on the data from language acquisition: Nouns are acquired first by children who have ‘perfect grammar’, equipped with the innate principles of universal syntax that allow them to master any language. Child language abounds in ‘verbless’ and ‘copulaless’ constructions. These structures are preserved in English in small clauses, such as *We consider* [_{SC} *Mary a friend*], for example. Furthermore, many languages construct sentences of the kind *Mary is smart* without a copula.

Across language systems, nouns have a special status that ranks them higher than verbs.³⁰ Certain languages have a very restricted number of verbs. For example, the aboriginal language Jingulu spoken in Australia has only three verbs: *do*, *go*, and *come*. Igbo (Ibo), a language of approximately 18 million speakers in Nigeria, does not have verbs at all. Instead, Igbo uses clusters termed ‘inherent complement verbs’ (ICV) that have the structure *–gbá* plus a noun. The root *gbá* is the only root in Igbo “devoid of meaning”, and the most productive one (Chinedu Uchechukwu, p.c.; see also Uchechukwu 2004). Here are some

²⁹ For reasons already given, languages with min-phases always have max-phases, while the max-phase group may in principle (but not necessarily) have min-phases. An example appears to be Icelandic that has ECM-constructions found in languages with max-phases. It also has dative experiencer constructions characteristic of languages with min-phases (e.g., the equivalent of *John.NOM me.DAT likes* meaning ‘I like John’). Such a min-phase is I-AppIP [*John.NOM_{NP} me.DAT_{NP}*]. Moreover, certain dialects of English appear to have an I-AppIP phase by allowing constructions such as *A cake was baked Mary*.

³⁰ Additional evidence comes from iconic languages of children of deaf parents. Deprived of formal linguistic input, these children simultaneously invent languages in which the gesture for *give* is associated with three noun phrases, the gesture for *kick* with two, and the gesture for *sleep* with one (Lidz & Gleitman 2004).

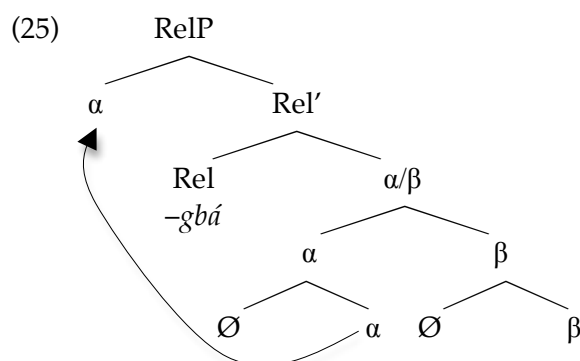
examples of Igbo clusters: *-gbá egwú* ‘dance a dance’ — *egwú* ‘dance’, *-gbá igwè* ‘ride a bicycle’ — *igwè* ‘bicycle’, *-gbá ákú/egbè* ‘shoot’ — *ákú* ‘arrow’/ *égbè* ‘gun’, *gbá úkwú* ‘kick’ — *úkwú* ‘foot’, *-gbá ọsọ* ‘run a race’ — *ọsọ* ‘race’, *-gbá motò* ‘travel with a vehicle’ — *motò* ‘vehicle’, etc.

The structure with ICV in Igbo linguistics has always been problematic for analysis. The first characteristic that differentiates its use from light verbs in other languages is that it is a regular linguistic means. The second is that these structures do not have any simple verb equivalent. As a matter of fact, *gbá* cannot be considered equal to a light verb: In expressions *take a leap*, *take a leak*, etc., there is no sharp divide between word and phrasal special meanings (Marantz 1997). In contrast, in Igbo, the semantic meaning of *-gbá*-clusters encodes the intrinsic connection between two key arguments, agent and theme, based on the primary function of the theme with respect to the agent. For example, the basic function of a car is to carry passengers. Accordingly, *-gbá motò* means ‘travel with a vehicle’; it does not mean ‘repair a vehicle’ or ‘sell a vehicle’.³¹

For Igbo, we postulate a Relational Phrase (RelP) whose head Rel is expressed overtly as a semantically vacuous element *-gbá* that establishes a relation between individuals (similar to I-Appl):

$$(24) \text{ [RelP Spec [Rel-}gbá \text{ [} \alpha, \beta \text{]}]}$$

Igbo clusters make explicit a hierarchical distribution of arguments in the absence of a verb. In a label-free representation of argument structure, agent is the first element to be \emptyset -merged to form a singleton set $\{\alpha, 0\}$, type-shifted to α , and then moved to [Spec,RelP]:



³¹ Note that inflected *-gbá* roots are not semantically empty: For example, *-do* is a suffix that expresses ‘fixation of the activity’ in *-gbá-do*. Other roots (e.g., *-tu*, *-kpa*, *-ma*) check semantic features of the nouns they are combined with, such as ‘animacy’ and ‘shape’. This feature-checking is similar to what is reflected as the *SER/ESTAR* alternation in Spanish and Portuguese. The choice of a particular copula is consistent with a \pm permanency feature of the predicate: *SER* is chosen over *ESTAR* when ‘sourness’ is a permanent property of the subject.

- (i) a. Os limões são [SER] ácidos. / *Os limões estão [ESTAR] ácidos.
 the lemons be.3PL sour / the lemons be.3PL sou
 ‘The lemons are sour.’
 b. As maçãs estão [ESTAR] ácidas. / *As maçãs são [SER] ácidas.
 the apples be.3PL sour the apples be.3PL sour
 ‘The apples are sour.’ (Costa 1998)

In the propositional setting, verbs cannot be eliminated. In contrast, from the point of view of Fib-like logic, the operation Merge is unconstrained, and any two successive elements may be merged to form a part of recursive system. If a certain type of phase can be defined as non-propositional, then EM can be represented as a mechanism that establishes the hierarchy of α and β , depending on whether α or β is \emptyset -merged first. The representation $\{\{\alpha, \emptyset\}, \{\beta, \emptyset\}\}$ in (26a) below is chosen over $\{\alpha, \beta\}$ in compliance with the NL-requirement: The sum of terms needs to be represented at each level.

Thus, the core EM operates on two symmetrically conjoined elements — α , β . The ‘argument-oriented’ mechanism establishes a hierarchical relation between α and β in some *relational* configuration RP — this means that its R carries a certain feature [R] that triggers the selection. In principle, either α or β can check the R-feature. The choice of the element depends on which sum undergoes EM first: If α is \emptyset -merged first, then α is ranked higher (26b).

- (26) a. $[_{RP} \mathbf{RH} \ [[\alpha, \emptyset], [\beta, \emptyset]]]$
 b. $[_{RP} \alpha \ [\mathbf{RH} \ [\beta, \emptyset]]]$

The requirement of EM to disregard order in favor of hierarchy is evident in the following.³² When asked to complete a sentence, readers preferred conjuncts with a shared subject over object conjuncts, and both over clause conjuncts (Hoeks & Hendriks 2005, from which the following examples are taken). S-coordinated sentences such as (27) were used, the first of which was temporarily ambiguous, whereas the latter served as a control sentence, made unambiguous by inserting a comma after the first object NP.

- (27) a. The model embraced the designer and ...
 b. The model embraced the designer (,) and the photographer opened a bottle of expensive champagne.
- (28) a. The model *embraced the designer and laughed*. VP-conjunct
 b. The model *embraced the designer and the photographer*. NP-conjunct
 c. *The model embraced the designer, and the photographer opened a bottle of expensive champagne*. TP-conjunct

Language users strongly prefer to continue a fragment such as (27a) for VP-coordination (28a). The second NP was interpreted by the readers as the object of the first clause (28b) rather than the subject of the second clause (27c). Both sentences *The model embraced the designer and laughed* and *The model embraced the designer and the photographer* were ranked higher than the one that had conjoined clauses, such as *The model embraced the designer, and the photographer opened a bottle of expensive champagne*. An account for the above-mentioned differences can be provided if VP-conjuncts are selected because both VPs share the same agent for

³² Kayne's (1994) Linear Correspondence Axiom derives linear order from strict asymmetric c-command. Linearization applies only at the level relevant for pronunciation — Spell-Out (Chomsky 2000).

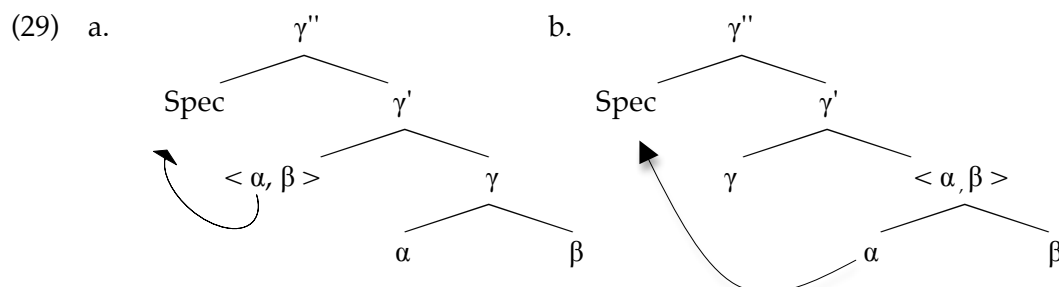
both verbs, ranking (28a) higher than (28b). Theme is next in the hierarchy of arguments; hence, (27b) is selected rather than (28c). The conclusion is that not all conjuncts are equal, and preference is given to the structure that identifies agents first, before a verb is introduced.³³

4.2. Word Order: Subject-First

Grammatical linguistic expression is the optimal solution, the reason why a particular word order 'Subject-first' is preferred across languages. In this section, it will be shown that cross-linguistic differences regarding the order of major constituents (Subject–Object) reflects the ways the system implements the notion 'preference', which attests to the intrinsic hierarchy of arguments. The SO order remains constant in the majority of languages (96%, Dryer 2005); SOV (rather than SVO) is the predominant pattern. The highest preference is given to languages that are either SO-first, or S-first. The canonical word ordering in optimal terms is SOV, SVO, VSO, VOS, OVS, and OSV.³⁴

The introduction of R-function as a means of hierarchical prioritization is offered as an account for the ranking of word order across languages. The structure $\{\alpha, \beta\}$ is *symmetrical*; α and β share an equal chance for movement. The Relational head R takes a pair $\{\alpha, \beta\}$ and establishes a hierarchy of elements in RP. The choice of which element is ranked higher depends on which sum is merged first. If α is \emptyset -merged first, α is displaced first. The output of the function R is an *hierarchically* ordered pair — either $\langle \alpha, \beta \rangle$ or $\langle \beta, \alpha \rangle$. The order $\langle \alpha, \beta \rangle$ is preferred to $\langle \beta, \alpha \rangle$. In our system, α corresponds to Subject and β to Object. Once S and O are ordered in RP, SO undergoes (Verb)-linearization. It has two options, with the first ranked higher than the second:

- Constituent SO is displaced: The resulting order is either $\langle \langle \alpha, \beta \rangle, \gamma \rangle$ or $\langle \gamma, \langle \alpha, \beta \rangle \rangle$, where γ is V; $\langle \langle \alpha, \beta \rangle, \gamma \rangle$ (SOV) is preferred to $\langle \gamma, \langle \alpha, \beta \rangle \rangle$ (VSO) (29a).
- S is displaced: The resulting word order is $\langle \alpha, \gamma, \beta \rangle$ (SVO) (29b).



³³ Identification of arguments and their hierarchical relations takes place prior to lexical selection: Evidence comes from the analysis of verb formation (Hale & Keyser 2002). Conflation of N and V in verbs such as *to saddle* and *to shelve* is possible only from complement position, which results in *to saddle the horse* and *to shelve a book* (compare #*to horse the saddle*, #*to book the shelf*). Nouns *saddle* and *shelf* can participate in the N/V conflation, but *horse* and *book* cannot because hierarchical selection of themes (*horse*, *book*) precedes lexical formation.

³⁴ It is evident that language systems are symmetrical (SOV/VSO, SVO/OVS, VSO/OSV), which confirms the idea of SO/OS parallelism.

In Object-first languages, R takes a pair $\{\alpha, \beta\}$ with an output of the ordered pair $\langle \beta, \alpha \rangle$ (OS), then the verb merges with OS. These are the options:

- The whole constituent OS is merged with V: The order $\langle \gamma, \langle \beta, \alpha \rangle \rangle$ (VOS) is preferred to $\langle \langle \beta, \alpha \rangle, \gamma \rangle$ (OSV).
- The first constituent O is merged with V: $\langle \beta, \gamma, \alpha \rangle$ (OVS).

It may be argued, however, that even though S+O (in SO languages) and O+S (in OS languages) in some cases display syntactic independence such as moving as a constituent, it is far from being typical or unmarked. This can be explained if movement is re-evaluated as the ‘internal’ version of Merge, thus not an ‘imperfection’ of language. The *internally* merged elements A, B have to be independent to occupy positions in a tree that are justified by the principles of efficient growth. However, in a symmetrical representation of *externally* merged arguments, an equal status is assigned to each of \emptyset -merged elements at some level, which is why conjoined structures such as bare nouns in conjunctions move as one constituent. In this sense, word order is a true reflection of the argument-centered syntactic primitive characterized by symmetry.

4.3. Symmetrical Conjuncts

The analysis under development shifts the focus from verb to the noun, from the propositional to the non-propositional logic of syntactic representations. The conclusion we have arrived at is that a minimal syntactic domain (phase) can be defined in non-propositional terms, such as a *relation between individuals*. The key requirement of the computational system of human language now includes an argument-centered configuration. As was already shown, a lower part $[_{XP} X]$ of $[_{VP} V [_{XP} X]]$ represents a phase in certain languages, contrary to what had been previously assumed.

In the present system of N-Law application, there is every reason to believe that a non-linear representation is characterized by *symmetry* of the basic form $\{\{\alpha, \emptyset\}, \{\beta, \emptyset\}\}$.³⁵ Recall that \emptyset -Merge at the bottom level of the tree is necessitated by the requirement to induce a progressive cycle implemented by sums rather than single elements; $\{\{\alpha\}, \{\beta\}\}$ is preferred over $\{\alpha, \beta\}$.³⁶ *Symmetrical conjuncts* are the core syntactic primitives, while displacement obeys the requirement to obtain a linear (asymmetric) order. Thus, the true representations underlying syntactic constructs can be characterized within a remarkably weak formalism of what we can call *conjunctivism*.³⁷

³⁵ See Moro (2000) on the possibility of symmetry at base structure, resolved into asymmetry by Spell-Out. Kratzer’s (1996) argumentation that the subject should be introduced by a separate predicate opposes the view presented here.

³⁶ Linguistic evidence suggests that certain lexical items that participate in conjunctions are \emptyset -branching projections, e.g., prepositional heads (*up and down the road*) and bare nouns (*cat and dog, knife and fork*). It is well known that conjuncts behave differently from other syntactic structures that can be derived from X-bar schema: Movement of a sub-part of a conjunct is prohibited.

³⁷ Conjunctivism says that *absolutely all* semantically relevant syntactic concatenation expresses conjunction (Pietroski 2005).

5. Species-Specific Properties of FLN

Hauser *et al.* (2002) argue that FLN may have evolved for reasons other than language. Gallistel *et al.* (2006) arrive at the following conclusion:³⁸

[T]he nonverbal system for arithmetic reasoning with mental magnitudes precedes the verbal system both phylogenetically, and ontogenetically. [...] The special role of the natural numbers in the cultural history of arithmetic is a consequence of the discrete character of human language, which picks out of the system of real numbers in the brain the discretely ordered subsets generated by the nonverbal counting process, and makes these the foundation of the linguistically mediated conception of number.

(Gallistel *et al.* 2006: 270-271)

In this part, rather than trying to identify the driving force behind the evolution of FLN from a non-verbal to verbal form, we will continue approaching language as part of a general natural system, while continuing our search for the criteria that single out this particular computational mechanism as species-specific.

As previously discussed, an important property of FLN is recursion. Is it possible to have a non-recursive human language? Recently, a claim was made by Everett (2005) that Pirahã, a language spoken by approximately 250 speakers in Amazonas, Brazil, lacks a specific recursive property exemplified as embedded clauses in other languages. Nevins *et al.* (2007) argue that these grammatical "gaps" are incorrectly analyzed by Everett — most of the properties under discussion are familiar from languages whose speakers lack the cultural restrictions attributed to Pirahã, a language of the so-called *immediate experience* restriction.³⁹ Pirahã has possessive constructions such as in (30) but not in (31a); however, the same absence of constructions such as *John's mother's hat* can be found in German (31b). Furthermore, the language cannot be claimed to lack embedded clauses. In displaying VO word order where the object is a clause, Pirahã, an OV language, shows VO in a post-verbal clausal complement (32). This is a choice made by many other languages.

³⁸ Blakemore & Frith (2005) observe that patients with an impaired system of calculation (summation, subtraction) still preserve the ability to estimate quantities, confirming the assumption that basic mental representations are continuous.

³⁹ Pirahã uses a special copula (3rd person pronoun) to distinguish between individual- and stage-level predicates that express a distinction between permanent and temporary qualities, just as Hebrew does (Soschen 2003). It follows then that Pirahãns do differentiate between types of *experience*.

- (i) *Pirahã*
 Giopaíxi hi sabí-xi.
dog COP.3SG wild
 'The dog is really wild.'
- (ii) *Hebrew*
 a. Dani hu nexmad.
 Dani he.3SG nice
 'Dani is a nice person (indeed).'
 b. Dani nexmad haiom.
 Dani nice today
 'Dani is nice today.'

- (30) a. John's car *English*
 b. Hans-ens Auto *German*
- (31) a. [John's car's] motor *English*
 b. *[Hans-ens Auto]-s Motor *German*
- (32) hi ob13-áaxái [kahaí kai-sai]
 3 see/know-INTNS arrow make-NOMLZR
 'He really knows how to make arrows.' (Nevins *et al.* 2007)

While the property of recursion most probably should be considered species-specific and thus attributed to all human languages, infinity is another feature that makes FLN crucially different from other discrete systems found in nature. There is no limit to the length of a meaningful string of words: There are ten-word sentences, twenty-word sentences, and so on, indefinitely. These properties are exemplified in a well-known nursery rhyme 'The House That Jack Built'. In the rhyme, each sentence X_k with a number of words n is succeeded by a sentence X_{k+1} with a number of words $n+m$: $X_{k+1}(n) = X_k(n+m)$, $X_2(n) = X_1(n+4)$, ..., $X_5(n) = X_4(n+4)$, $X_6(n) = X_5(n+8)$, ...^{40,41} Language is also discrete: There are neither n -and-a-half words nor n -and-a-half-word sentences (Chomsky 2000). Syntactic units are also continuous: Once a constituent is formed, it cannot be broken up into separate elements. For example, *The dog chased the cat* is the basic representation; in a passive construction *The cat was chased* _{the cat} *by the dog*, the NP *the cat* moves to the beginning of the sentence only as a constituent. Hence, *Cat was chased the* _{cat} *by the dog* is ungrammatical.⁴²

The application of N-Law logic to the analysis of syntax results in the re-evaluation of FLN as part of a larger mechanism designed for continuation of movement. A general physical law that appears in every living organism applies to the universal principles of grammar: FLN complies with the maximization requirement as well. The Fib-rule accounts for the limitations imposed on the number of arguments in thematic domains, and it also explains why syntactic derivations proceed by phases. Merge is an essential part of a unique recursive

⁴⁰ "This is the house that Jack built₁. This is the malt That lay in the house that Jack built₂. This is the rat, That ate the malt That lay in the house that Jack built₃. This is the cat, That killed the rat, That ate the malt That lay in the house that Jack built₄. This is the dog, That worried the cat, That killed the rat, That ate the malt That lay in the house that Jack built₅. This is the cow with the crumpled horn, That tossed the dog, That worried the cat, That killed the rat, That ate the malt That lay in the house that Jack built₆."

⁴¹ In contrast, other biological systems exhibit finiteness. For each kind K of flower (a, b, c, d, e, ...), there is a fixed number of petals X that corresponds to a Fib-number: $K_a=X(3)$, $K_b=X(5)$, $K_c=X(8)$, $K_d=X(13)$, $K_e=X(21)$, $K_f=X(34)$, ... $X(3) = X(3-1) + X(3-2)$ [lily, iris], $X(5)$ [buttercup, wild rose, larkspur, columbine], $X(8)$ [delphiniums], $X(13)$ [ragwort, corn marigold, cineraria], $X(21)$ [aster, black-eyed susan, chicory], $X(34)$ [plantain, pyethrum], $X(55)$, $X(89)$ [michelmas daisies, the asteraceae family].

⁴² I am indebted to an anonymous reviewer for the following remark: "Saying that the ungrammaticality of *Cat was chased the by the dog* is due to the fact that *the cat* can move only as a constituent raises the question of why *cat* cannot behave the same way and move as a constituent". As one possible explanation, a \emptyset -merged element behaves as a constituent at the level of EM but not in IM. EM establishes hierarchical relations only; there is no movement in EM.

mechanism exemplified as phases in syntax.

In the present work, the *impenetrability* of already formed constituents (as the result of a specific type-shifting operation) is viewed as *the key requirement of FLN*. In contrast, segments comprising other GR-based systems of growth can in principle be separated from one another. Following from that, FLN as a sub-system of natural development based on optimal space filling can be represented graphically, representing both *discreteness and continuity of its constituents* (Figures 2 and 3 below).

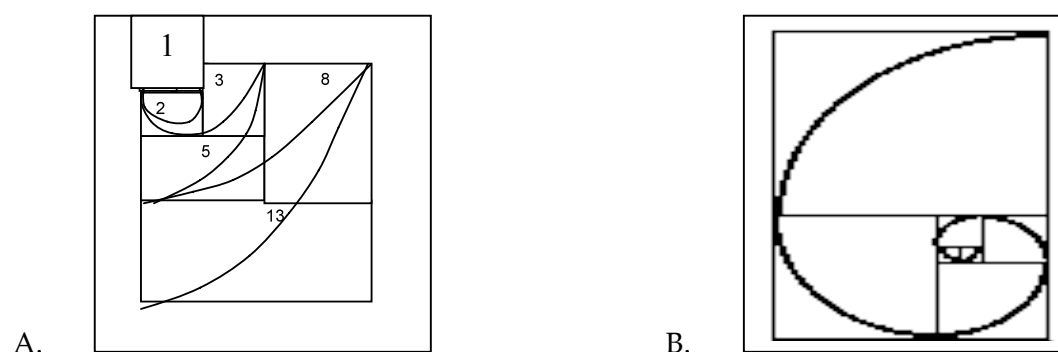


Figure 2: Pendulum- (A) vs. spiral-shaped (B) GR-based systems

Depending on whether the phase is complete or not, each constituent may appear either as a part of a larger unit or the sum of two elements. For example, one line that passes through the squares '3' and '2' connects '3' with its part '2'; the other line indicates that '3' as a whole is a part of '5'.

The *pendulum-shaped graph* to the left is contrasted with a non-linguistic model to the right where one line connects the preceding and the following elements in a spiral configuration of a sea-shell. This system does not comply with IC. For example, '3' is a sum of '2' and '1', while '2' is comprised of separate elements '1' and '1'. There is no line that connects '2', '3', and '5' in such a way that '2' as a whole is a part of '5' (Figures 2B, 3B).

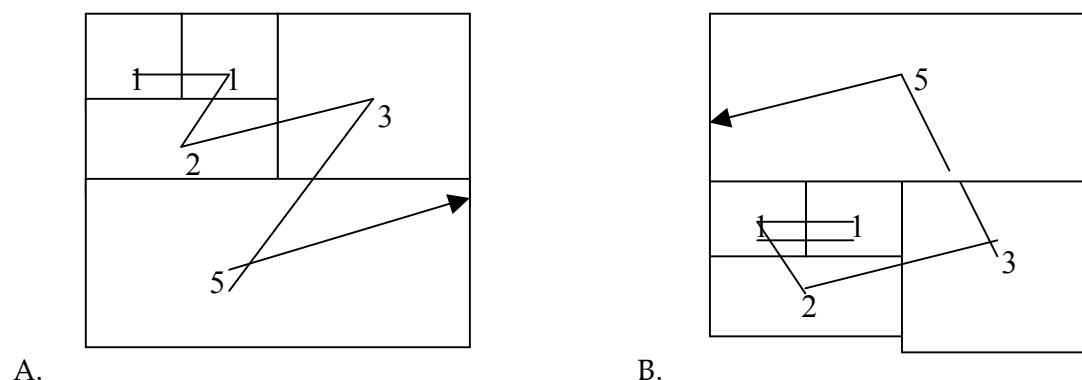


Figure 3: Configurations A and B (Figure 2) made explicit

The distance between the ‘points of growth’/segments in the above representations can be measured according to GR, the requirement of optimization. The structure of FLN complies with N-Law; however, in contrast with other natural systems of growth, each element appears as either discrete (the sum of two elements) or continuous (part of a larger unit).

6. Summary and Conclusions

This analysis, applied to the sequence of nodes in syntactic trees along the lines of N-Law, has focused on a functional explanation of binary branching, labeling, and the properties of the existing types of Merge. The optimization requirement justifies the basic principle of organization in both External and Internal Merge, the two forms of a basic Merge. EM either returns the same value as its input (\emptyset -Merge), or the cycle results in a new element (N-Merge). EM is responsible for the number of arguments, which corresponds to the number of positions available to the element adjoining a Fib-like tree. Maximal thematic domains incorporate all possible argument-based representations. This argument-centered approach shifts the focus from verb to noun, from the propositional to the non-propositional logic of grammar.⁴³ The minimal building block that enters into linguistic computation is identified as a symmetrical conjunct, which expresses a relation *between individuals* (rather than *between individuals and events*). As a result, the true structure of language is characterized within a remarkably weak formal system, which is expected to develop into a more complex one to handle a broader range of data.

IM is induced by the necessity that lexical items must obtain a linear (asymmetric) ordering. Movement depends on the qualification of phrases as phases. Any phrase can in principle constitute a phase. Phase heads are characterized by the ability to project specifier positions to ensure continuation of movement. Presumably all languages have maximal phases; in addition, synthetic (inflected) languages have minimal (i.e. Individual Applicative) phases. The label-free phases can be compared according to their configurations. As one example, this comparison provides an account of why languages with minimal phases lack ECM structures.

By developing the idea that linguistic structures have the properties of other biological systems, we have reached some conclusions concerning the underlying principles of the computational system of the human language. The Faculty of Language obeys the rule of optimization. However, in contrast with other GR-based natural systems of efficient growth, at some level each syntactic constituent may appear as either discrete or continuous. The impenetrability of already formed constituents — which in itself is a result of a unique type-shifting operation — is viewed as the key condition imposed upon FLN.

⁴³ The argument-centered model of syntactic representations is experimentally supported in Soschen & Slavova (2008).

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